CHAPTER 6

Fish Habitat Suitability Index

Joel C. Trexler[1], William F. Loftus[2], and Kenneth C. Tarboton[3]

General Description

Fish species are primary ecosystem indicators for the Everglades. Fishes provide the food for other species, including alligators and birds. During flooding, populations of small fish (e.g., eastern mosquitofish, **Figure 6-1**), crayfish, etc., are nourished by detritus and seasonal algal growth and, because they are relatively protected in the shallow marshes from large predatory fish, they reach large numbers. During the dry period, the fish are concentrated into pools and depressions by receding waters (DeAngelis et al. 1998). The fauna of short- and long-hydroperiod areas differ: in the short-hydroperiod areas, fish and prawn densities are generally lower, whereas the crayfish density is higher (Roman et al. 1994).

Figure 6-1. Eastern mosquitofish (*Gambusia holbrooki*) is typical of small fish species found in the ridge and slough parts of the Everglades.

1. Florida International University
2. United States Geological Survey
3. South Florida Water Management District

The fish suitability index was developed based primarily on the results of studies using a 10-square foot throw trap. Sampling at this spatial scale produces results most reflective of the small-sized fishes that are numerically dominant in the Everglades (generally less than 3 inches in maximum adult length). Those species comprise the bulk of food for many wading birds and are considered an appropriate target group for assessing habitat quality in the context of food web function in this ecosystem. A different function would have been produced had our emphasis been on fish species with larger adult sizes, such as Florida gar and yellow bullheads, or game species that are important to fisherman. It was decided to not emphasize large-bodied fish species because angling is largely limited to canals and large species are rather uncommon in marshes and not often taken by wading birds.

Hydrologic Variables

Based on empirical data from freshwater marsh sampling in Everglades National Park and Water Conservation Area (WCA) 3, annual estimates of fish densities decline when water levels fall below the ground surface of the marsh for even short periods of the year (Trexler and Loftus 2001). At these times, fishes are forced into refuges that are limited in area, depth, and number. The availability of these refuges creates bottlenecks of fish population size that require several generations of unrestrained growth (prolonged period of flooding) before their influence is lost. Time-series analyses indicate that annual minimum water depth is a good measure of the effects of recent hydrologic fluctuation. It is generally correlated with other measures of hydroperiod, but explains more variation in our data than parameters such as annual average water depth (Trexler et al. 2002, 2003).

In natural refuges, such as marsh depressions and alligator ponds, the farther below ground surface the water falls, the more predation occurs, particularly among small fishes (Loftus, unpublished data; Howard et al. 1995, Kobza et al. 2004). Larger fishes suffer mortality from the effects of crowding and of low dissolved oxygen levels (Nelson and Loftus 1996). Canals are the exception in that they are deep, long linear habitats that offer refuge of differing value to fishes depending on their body size (Howard et al. 1995). Within a zone of up to approximately 1.5 miles from canals, marsh areas may be influenced by dispersal of fishes from the canals, and as such cannot be properly predicted by minimum water depth alone. Canals also accumulate large populations of large piscivorous species (relative to marshes) that may affect marsh fish densities within this zone. Such edge effects should be considered when interpreting output of this fish suitability index.

Empirical data demonstrate that the small-bodied fish component of the community requires approximately three years of constant inundation to recover fully from the effects of a dry-down (Trexler and Loftus 2001). At that point, the community characteristics of long-hydroperiod marshes regain predisturbance conditions. When the recurrence of a drydown event exceeds seven to eight years, particularly in marshes where the water levels have been kept deep and stable, the small fish component appears to decline in density, perhaps as a result of predation by larger-bodied species (Chick and Trexler, unpublished manuscript; Loftus and Eklund 1994, Kushlan 1976). The density of fishes is dominated by hydrologic events in marshes that typically dry at a frequency of less than every three years. Thus, the shorter the hydroperiod, the lower the fish density in general, and the lower the correlation between density and time since drydown (Trexler and Loftus 2001).

A high correlation has been shown between fish density estimated from a wide range of hydroperiods in marshes in Everglades National Park and WCA 3 and a long-term average hydroperiod (Trexler and Loftus 2001). Up to a point, the longer the flooding period, the more fish per unit area are present at the site. The relationship is not linear and not monotonic. However, the maximum density of small fishes is limited at sites where hydroperiods are so long that drydown events occur less often than one per ten years. The origin of this nonlinearity is probably in the development of piscivorous fish communities in the longest-hydroperiod habitats (Chick and Trexler, unpublished manuscript). Also, this relationship disregards the effects of nutrient inputs that at low and intermediate levels also lead to increases in fish densities (Trexler and Loftus 2001, Turner et al. 1999). Aside from anthropogenic nutrient enrichment, natural variation in local nutrient availability can decrease the predictive ability of this suitability function.

Habitat Suitability Function for Fish

The fish habitat suitability function is based solely on the number of years of constant inundation since last drawdown (t in years) and is applicable to the ridge and slough landscape. The fish suitability index as a function of time since the last drawdown to dry conditions is as follows (**Figure 6-2**):

$$SI_{fish} = 1.052[1 - \exp(-0.9663(t + 0.10336)]$$

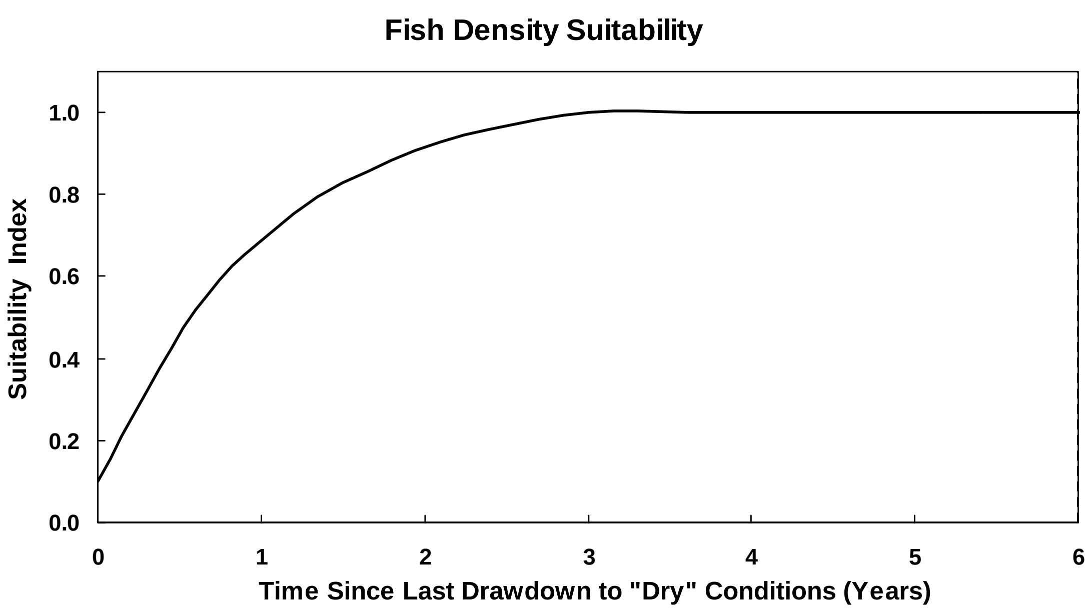


Figure 6-2. Fish suitability as a function of time of constant inundation from last drydown.

The fish suitability index above was computed from South Florida Water Management Model version 3.5 (SFWMM) and Natural System Model version 4.5 (NSM) output (31 years). The SFWMM grid cells applicable to the fish suitability index are presented in **Figure 6-3**.

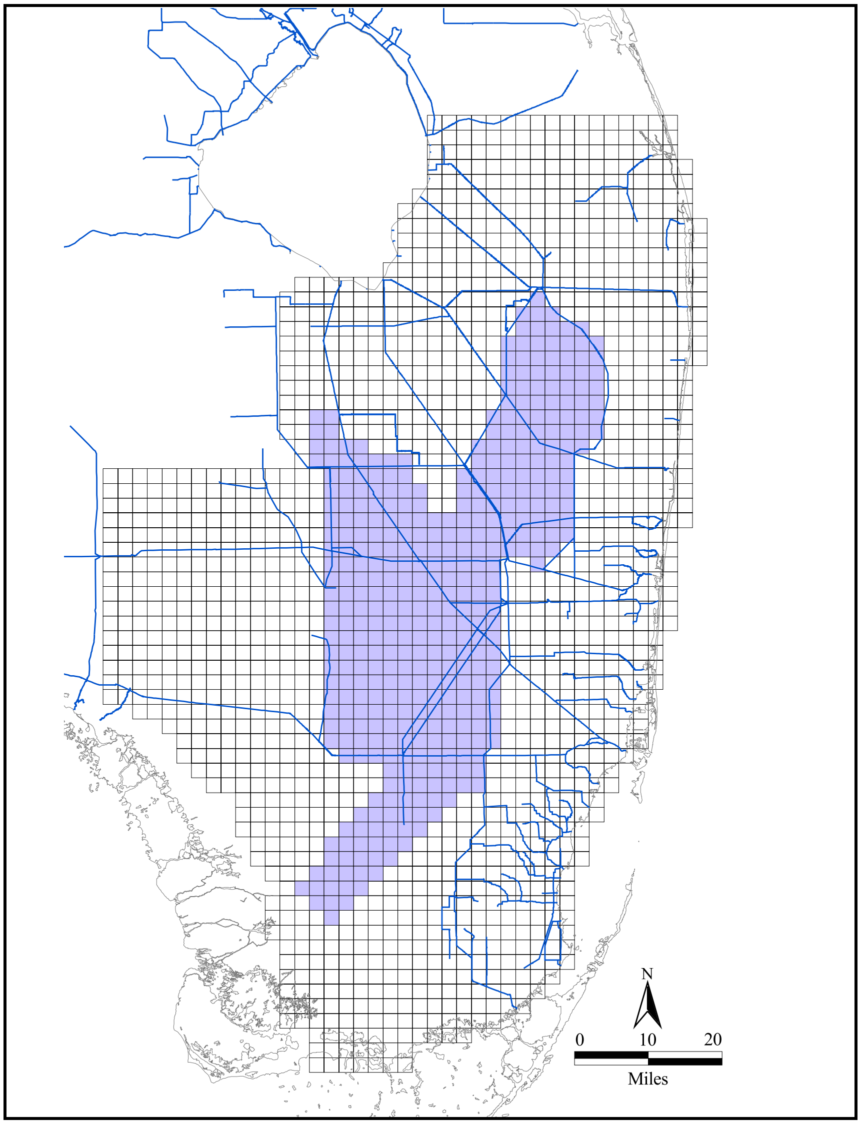


Figure 6-3. SFWMM grid cells applicable to the fish habitat suitability index.

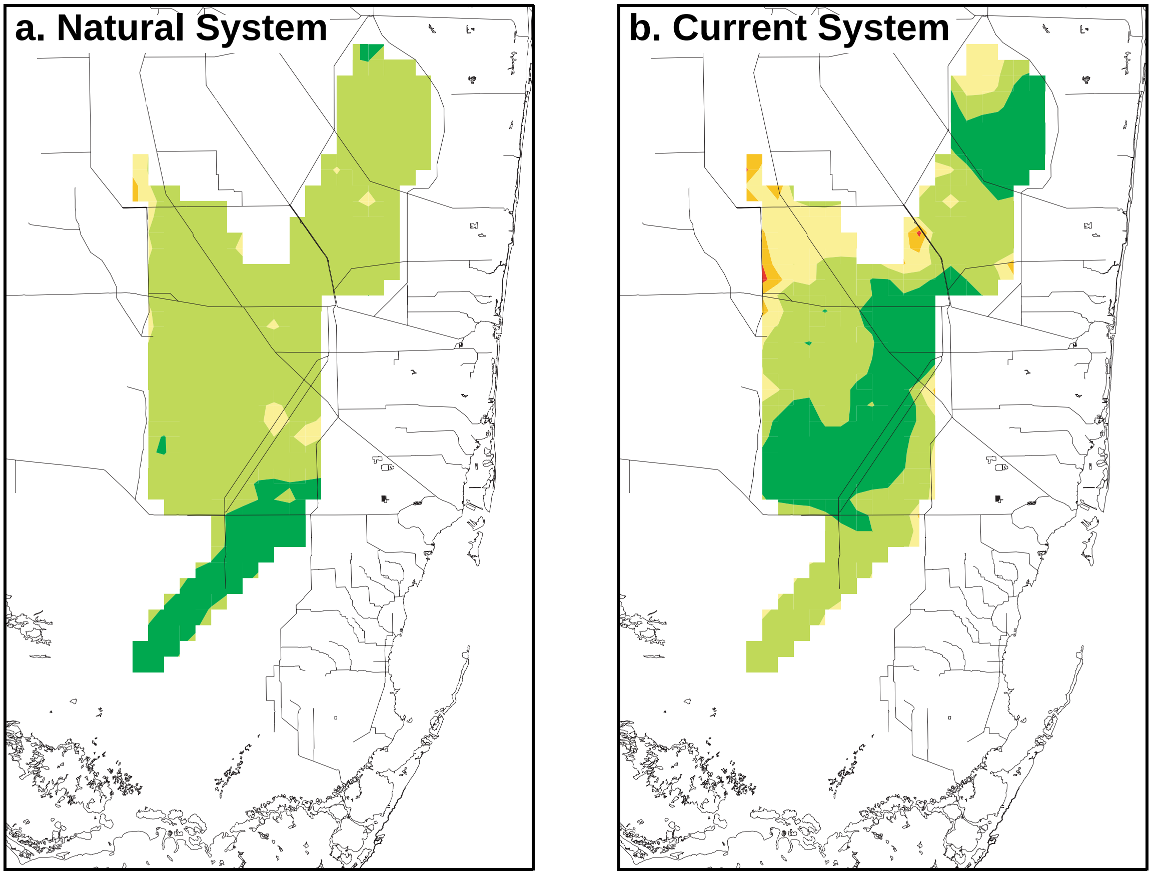
Results

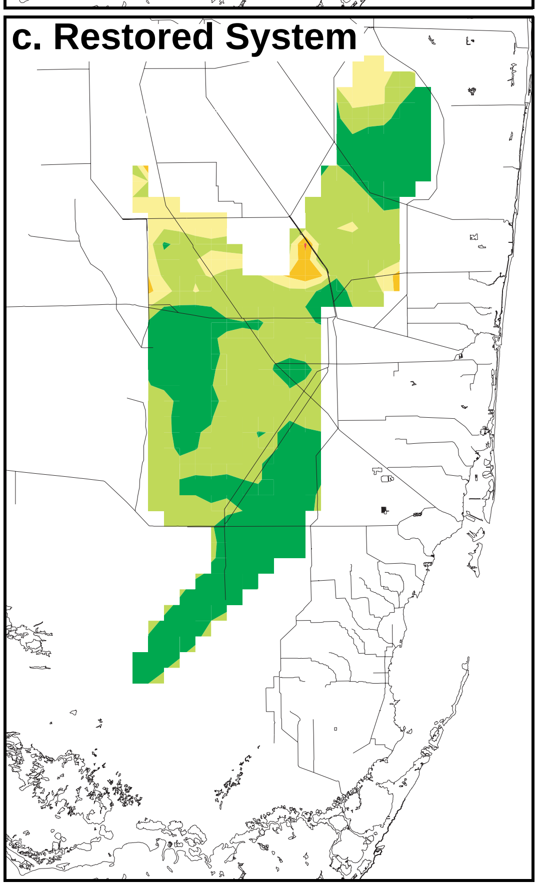
Results from the above habitat suitability function for fish should be interpreted with great care. Short-hydroperiod marshes will always appear to be “less suitable” because they naturally have lower density of fishes than long-hydroperiod marshes, though some species actually reach their maximum density in short-hydroperiod marshes. In general, however, habitats in which surface water dries each year are harsh for fishes.

But an important point is that the Everglades has always had such habitats along its margins. Thus, it would not be desirable to seek to maximize a habitat suitability index for fish across the landscape that would create an ecosystem unlike the predrainage Everglades. Rather, fish suitability should be compared to that obtained for the natural system with the goal of striving to obtaining a similar suitability distribution to that of the natural system.

Initial results indicating the performance of the fish suitability index are shown for natural, current, and restored systems in **Figure 6-4**. In the natural system (**Figure 6-4a**), the northern portion of the ridge and slough landscape is fairly well suited (0.6) to fish habitat with little effect of increased drydown at the marsh edges. Deeper water and fewer drydowns in the Shark River Slough area indicate better suitability (0.8). In the current system **Figure 6-4b**, increased drydown in the northern parts of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LWNR) and WCA 3 result in lower suitability (approximately 0.4) than in the natural system, while deeper water and fewer drydowns in the southern part of LNWR and WCA 3A to the west of the L-67 canal result in higher suitability (0.8) than in the natural system. Fish suitability in Shark River Slough is lower in the current system (0.6 to 0.8) than in the natural system. In the restored system simulation (**Figure 6-4c**), drydowns in northwestern WCA 3A are not as frequent as in the current system and the resultant fish habitat suitability is closer to that of the natural system. Some edge effects with lower fish habitat suitability occurs along the northern edge of WCA 3A and the northern parts of LNWR. Fish habitat suitability in Shark River Slough in the restored system is similar to that of the natural system, while deeper water and fewer drydowns in the central part of WCA 3A and WCA 3B result in higher fish suitability values (0.8).

Examination of results from fish habitat suitability for the natural, current, and restored system, discussed above, provides useful information that highlights areas requiring further examination and provides insights that could lead to further development of the fish habitat suitability index. Less suitable habitat at the margins of the ridge and slough landscape, not evident in the natural system simulation, is more evident in the current and restored system simulations. This may be because the fish habitat suitability index was not applied to the marginal marl prairie areas adjacent to the ridge and slough landscape in which a decline in suitability would have been evident in the natural system simulation. Alternatively, further examination of the natural system simulation or refinement of the fish suitability index may be necessary. More suitable fish habitat in the deeper impounded areas of LNWR and to the northwest of the L-67 canal in the current system, compared to the natural system, will not necessarily translate into increased small fish density in these areas because the habitat may also be more suitable to predator species. The fish habitat suitability index provides information about where habitat is potentially improved but should be used in conjunction with more complex species-specific models to provide more definitive information on expected fish densities.





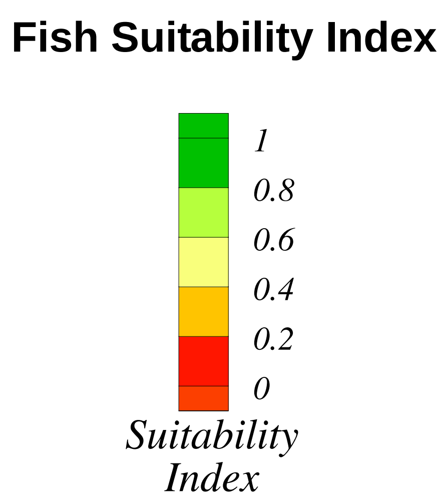


Figure 6-4. Mean annual fish suitability index for the a. natural system, b. current system, and c. restored system.

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